

Metabolic Rate and Ground Reaction Force during Motorized and Non-Motorized Treadmill Exercise

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The International Space Station (ISS) treadmill can be operated in the motorized (M) or non-motorized (NM) mode. Current in-flight exercise prescriptions include both M and NM treadmill exercise. The two modes may protect cardio-respiratory and musculoskeletal fitness differently, and understanding differences between modes may be useful for improving the efficacy of in-flight countermeasure prescriptions.

PURPOSE

To measure vertical ground reaction force (vGRF) and oxygen consumption (VO_2) at several velocities during exercise using a ground-based version of the ISS treadmill in the M and NM modes.

METHODS

Subjects ($n = 20$) walked or ran at 0.89, 1.34, 1.79, 2.24, 2.68, and 3.12 $\text{m}\cdot\text{s}^{-1}$ while VO_2 and vGRF data were collected. VO_2 was measured using open-circuit spirometry (TrueOne® 2400, Parvo-Medics). Data were averaged over the last 2 min of each 5-min stage. vGRF was measured in separate 15-s bouts at 125 Hz using custom-fitted pressure-sensing insoles (F-Scan Sport Sensors, Tekscan, Inc). A repeated-measures ANOVA was used to test for differences in VO_2 and vGRF between M and NM and across speeds. Significance was set at $P < 0.05$.

RESULTS

Most subjects were unable to exercise for 5 min at treadmill speeds above 1.79 $\text{m}\cdot\text{s}^{-1}$ in the NM mode; however, vGRF data were obtained for all subjects at each speed in both modes. VO_2 was ~40% higher during NM than M exercise across treadmill speeds. vGRF increased with treadmill speed but was not different between modes.

CONCLUSION

Higher VO_2 with no change in vGRF suggests that the additional metabolic cost associated with NM treadmill exercise is accounted for in the horizontal forces required to move the treadmill belt. Although this may limit the exercise duration at faster speeds, high-intensity NM exercise activates the hamstrings and plantarflexors, which are not specifically targeted or well protected by other in-flight countermeasures.